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Published Version

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Ahiale, E. D., Balcombe, K. and Srinivasan, C. ORCID: <https://orcid.org/0000-0003-2537-7675> (2020) Determinants of farm households' willingness to accept (WTA) compensation for conservation technologies in Northern Ghana. *Bio-based and Applied Economics*, 8 (2). pp. 211-234. ISSN 2280-6172 doi: 10.13128/bae-8931 Available at <https://centaur.reading.ac.uk/91256/>

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Identification Number/DOI: 10.13128/bae-8931 <<https://doi.org/10.13128/bae-8931>>

Publisher: Firenze University Press

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Determinants of Farm Households' Willingness to Accept (WTA) Compensation for Conservation Technologies in Northern Ghana

EVELYN DELALI AHIALE^{1,*}, KELVIN BALCOMBE², CHITTUR SRINIVASAN²

¹ Department of Agricultural Economics and Extension Education, University of Education, Winneba, Ghana

² School of Agriculture, Policy and Development, University of Reading, UK

Abstract. This paper examines the determinants of farmers' willingness-to-accept (WTA) in a hypothetical payment scheme for the adoption of stone and soil bunds in northern Ghana using contingent valuation data from 305 farm households. Bayesian estimation of the interval-data regression model is employed to obtain farmers' WTA and its determinants. Besides farmer and household characteristics, farm characteristics and socioeconomic and institutional variables such as soil fertility and previous participation in conservation projects increase and decrease willingness-to-accept respectively. The results suggest that costs of soil and water conservation payment schemes may be significantly decreased by careful targeting of households more ready to accept compensation.

Keywords. Conservation technology/practice, interval-data regression model, willingness-to-accept, Contingent valuation method, Payment for Environmental Services.

JEL Codes. Q18, Q56, Q57.

1. Introduction

Land degradation is one of the world's environmental concerns today. It can be regarded as a process that includes soil degradation and erosion. The main processes that lead to land degradation are soil erosion by water and wind; chemical changes such as acidification, salinization, and nutrient loss; and physical degradation through pressures such as compaction (Eswaran *et al.*, 2001; UNCCD, 2013). There is no consensus on the exact extent and severity of land degradation in the African region, there is however consensus that it is severe and widespread. Analyses of global land degradation indicate that Africa is especially susceptible to land degradation and is the most severely affected part of the world (Lal, 1995; Obalum *et al.*, 2012). An estimate of two-thirds of Africa's productive land is affected by land degradation and almost all the land area is susceptible to

*Corresponding author: abedella@yahoo.com

soil and environmental degradation (FAO, 2011; Jones *et al.*, 2013; UNCCD, 2013; Vlek *et al.*, 2008). In sub-Saharan Africa (SSA), in excess of 320 million hectares of land have been made unsuitable for agricultural purposes due to soil erosion, deforestation, overgrazing and mismanagement of land resources (Sant, 2001). Nabhan (1997) also reports that 67% of agricultural lands are affected by land degradation, with close to 490 million hectares displaying signs of erosion and declining fertility.

The issue of land degradation is of immense importance in Africa as majority of its population's livelihood is heavily reliant on natural resources. Agricultural productivity in the region is stagnating or declining, largely due to land degradation. Land degradation in Africa has thus been immensely detrimental to agricultural ecosystems and crop production consequently leading to increasing levels of food insecurity, loss of farm incomes, poverty, high mortality rates, other social vulnerabilities, migration and conflict (Gomiero, 2016; Hamdy & Aly, 2014; Hemant & Padmini, 2013; UNCCD, 2013). Land degradation thus has socioeconomic implications for African countries.

Soil and land degradation in Ghana was recognized decades ago, as since the 1930s, it has attracted considerable attention and concern (Agyepong, 1987; Benneh & Agyepong, 1990). Land degradation is affecting all parts of Ghana, however, the northern regions placed within the Guinea and Sudan Savannahs are the most vulnerable zones and the most degraded area of the country (Asiedu *et al.*, 2016; World Bank, 2006). Ghana had 35% of its land threatened by desertification particularly in the northern regions (Upper East, Upper West and Northern Regions) since the 1960s (Adanu *et al.*, 2013; Kenworthy, 1995). Land degradation in the northern regions of Ghana has thus rendered large tracts of croplands which were once fertile currently unproductive as such contributing to depleting farm income and food sources. As a result of land degradation, grasslands, woodlands and forests are being lost while natural water bodies are drying up due to prolonged droughts and deposition of sediments into water courses (Adanu *et al.*, 2013). Land degradation in Ghana, which is mainly as a result of soil erosion and soil nutrient depletion, has negative impact on farm productivity and environmental quality. The human-associated drivers of long-term soil and vegetation degradation in Ghana include unsustainable farming practices, removal of vegetation cover (including deforestation and overgrazing), mining activities, and urbanization and industrial activities caused by increased population growth pressures.

Agriculture remains an important sector in the Ghanaian economy contributing about 22% to the country's gross domestic product (GDP) and providing 44.7% of employment in 2013 (Aryeetey & Baah-Boateng, 2015). Agriculture also remains the main source of livelihood for many subsistence smallholder farmers living in rural Ghana. The agricultural activities of these smallholders is cited to be a key factor in promoting land degradation through the use of environmentally unsustainable cultural practices (Asiedu-Amoako *et al.*, 2016; Boardman *et al.*, 2003; Diao & Sarpong, 2007; Helming *et al.*, 2006; Senayah *et al.*, 1998). As agriculture is the major user of rural land, its relevance is not only in relation to its economic significance, but also its influence over the use of land in rural Ghana and its environmental health in general. With the relationship between land degradation, agricultural productivity and poverty well understood (Dasgupta & Mäler, 1995; Gomiero, 2016; Hamdy & Aly, 2014; Heath & Binswanger, 1996; Hemant & Padmini, 2013; Shetty *et al.*, 1995; World Bank, 1992), it is clear that land

degradation is a threat not only to national and household food security but the overall welfare of many households in Ghana.

In order to maintain agricultural productivity, reduce food insecurity and poverty, and improve environmental conditions, the Government of Ghana (GoG), international donor agencies and Non-Governmental Organizations (NGOs) have promoted soil and water conservation practices and technologies including soil and stone bunds. This has been done for several decades particularly in the Northern, Upper-East and Upper-West regions because they collectively constitute the most degraded part of the country.

Adoption of the promoted technologies has arguably been unsuccessful due among others to weak regulatory institutions which have restricted the 'command and control' interventions (Wunder, 2008). Farmers' inability to adopt soil and water conservation measures is mainly as a result of constraints resulting from market failures which lead to externalities like degradation. When externalities are present, government intervention has the potential to internalise these externalities. One potential intervention is Payment for Environmental Services (PES) in which incentive payments are made to resource managers in return for the adoption of conservation practices/technologies. Such external financial incentives may be crucial in ensuring that socially desirable levels of environmental services/goods (ES) are supplied and maintained since poor smallholder farmers may not be able to afford to maintain healthy environmental quality especially when large opportunity costs occur when conservation technologies/practices are adopted.

Soil and water conservation technologies (e.g., soil and stone bund) are technologies that preserve the integrity of soils and their water content, and they offer a number of on-farm and off-farm ecosystem services of value to society as well as on-farm productivity improvements. Stone and soil bunds are stone or soil walls built across a slope (along a contour) to act as a barrier to prevent run-off, therefore helping in reducing soil erosion and increasing water retention capacity of soil. They are often appropriate for gentle slopes (2-5%) (Diao & Sarpong, 2007). Ecosystem services from stone and soil bunds include: substantial flood and erosion control, substantial reduction in sedimentation of water bodies and its consequent improvement in water quality and aquatic life; reduction in leaching and deposition of fertilizers, herbicides and pesticides, i.e. generally improved landscape quality, etc. (Bingham *et al.*, 1995; Holland, 2004; Webb *et al.*, 2001). The adoption of soil and water conservation (SWC) technologies is aimed at returning a landscape to a condition where it can again provide the ES enumerated above after a period of degradation. Farmers can therefore be paid/compensated for the adoption of such technologies as soil and stone bund per unit area to produce the socially beneficial ES mentioned. Payments can be in the form of money, in kind, and access to resources and markets.

In order to know the optimum rate of public investment, the required level of compensation (WTA) necessary for encouraging agricultural households to adopt a conservation technology which produces ES must be ascertained. In addition, knowledge of the factors determining WTA also informs policy implementation by enabling the direction of payments towards those that are the most predisposed towards adopting the proposed technologies.

The current study therefore uses the contingent valuation (CV) method to estimate farmers' WTA for adopting stone and soil bunds in a hypothetical conservation plan/valuation scenario context. The method of elicitation within the CV employed allows

for uncertain responses so as to maximise respondent's engagement with the survey. It employs an interval regression model to estimate WTA and determines the factors influencing their WTA, having adapted this model to allow for uncertain responses.

Extensive literature exists on PES as an alternative intervention for environmental conservation. However, much of this has focused on parts of the world other than Africa leading to a dearth of knowledge on environmental values and the main factors influencing WTA for PES conservation practice/technologies for Africa and specifically for PES schemes in Ghana. This study fills this gap by building on previous studies, with a specific aim to determine the manner in which various factors influence WTA compensation for stone and soil bunds in northern Ghana. The manner in which various factors influence WTA for conservation technologies may be location and conservation practice specific. This study therefore serves to analyse these factors, so they can be understood in a way that enables better designed interventions and decision-making in Ghana.

The paper proceeds by first reviewing literature on valuation of the welfare impact of adoption of soil and stone bunds and the factors that influence farmers' preferences for or WTA for conservation practices in Section 2. The interval data regression model specification and estimation is presented in Section 3 while Section 4 discusses the field survey, data and variables. The results are presented in Section 5 and Section 6 discusses the results. The conclusions and policy implications is given in Section 7.

2. Literature review

2.1 Valuation of the welfare impact of adoption of soil and stone bunds

The contribution of a resource to human welfare forms the basis of the economic approach to the valuation of resources. An economic value is measured by the variations in welfare related to the variation in the quantity or quality of goods or services. Variations in environmental service flows can influence the welfare of individuals in complex ways and through both marketed or non-marketed activities (Shiferaw *et al.*, 2005). Interventions like adoption of soil and stone bund by farm households that lead, for example, to reduction in soil erosion apparently change the welfare of different members of the society. Welfare economics suggests that welfare values or changes are determined by individual preferences and measured by their personal assessment of changes in well-being (Bockstael *et al.*, 2000) or the extent to which they are willing to make trade-offs between scarce resources to obtain or preserve something.

Investments in soil and stone bund provide multiple economic and environmental benefits to different groups of people beside the adopting smallholder farm households. An impact evaluation of the interventions should therefore take into account any non-marketed ecosystem goods and services along with marketed economic benefits (Baker, 2000; Shiferaw *et al.*, 2005). The welfare gains from investments in soil and stone bund include the direct economic benefits (e.g., yield gains) and environmental benefits (e.g., sustainability benefits and ecosystem services) that have both use and non-use values to people. Indirect welfare benefits obtained from environmental improvements are justifiable components of the welfare changes related to any conservation interventions, and must be measured in impact evaluation (Shiferaw *et al.*, 2005). Total welfare benefit to people, therefore,

is the sum of the direct economic and indirect environmental benefits. Hence, the benefits accruing to soil and stone bund can be assessed as those captured privately by the farm household, which include the value of yield loss averted and/or yield gains which may be felt on-site by the farm household, and those external to the farm household that are captured publicly, whose value include the improvement in ecosystem services.

The valuation of changes in ecosystem services as a result of the adoption of soil and stone bund by farmers "needs to take into account both intended and unintended outcomes as different individuals may attach values for such changes because of the use benefits they derived, or any expected or conceived non-use welfare benefits" (Shiferaw *et al.*, 2005). The concept of total economic value (TEV), the usual and most appropriate framework for aggregating the value of non-market ecosystem goods and services and measuring welfare changes is a vital part of economic valuation (Pearce, 2002; Philcox, 2007). Economic values reflect the services of an ecosystem and not the economic value of that ecosystem (Nijnik & Miller, 2017).

The potential welfare changes or impacts as a result of soil and stone bund on groups of individuals differ, i.e., the farm household's welfare change is different from the welfare impact on the consumers of the ecosystem services accruing from soil and stone bund. Assessing the economic value of soil and stone bund can thus be done in two ways. First, the measurement "of how much better or worse-off a person is due to the variation in the quantity or quality of the service flow" and second, "the addition of the individual welfare variation (gains and losses or WTP/WTa) to assess the value of this variation for the entire society (Shiferaw *et al.*, 2005). The former is the focus of the current paper.

Total welfare gains include the direct economic benefits (e.g., yield gains) and indirect environmental benefits (e.g., ecosystem services) that have both use and non-use values to people (Shiferaw *et al.*, 2005). The benefits accruing to the adoption of soil and stone bunds can be assessed as those captured privately by the farm household, which include the value of yield loss averted and/or yield gains which may be felt on-farm by the farm household, and those external to the farm household (off-farm) that are captured publicly, whose value include improvement in ecosystem services. Direct use values comprise consumptive uses including the potential yield increase that may be associated with the adoption of the conservation technology and indirect use value is improvement in landscape quality. The non-use value of soil and stone bund includes improved and preservation of aquatic life, erosion control, and the reduction of the deposition of soil and agricultural chemicals into water bodies. For this study, the WTP or WTA indicates how the adoption of stone and soil bund impact on the welfare of participating farm households.

The benefits accruing to farmers by adopting soil and stone bunds are often below the total benefits created once public good values have been accounted for, leading to below optimal levels of resource supply. In the presence of high public good values, incentive payments for resource conservation may be necessary. There is dissimilarity between the average gross margin of adoption and non-adoption of conservation technologies/practices that result in conservation opportunity costs for farmers (Krishna *et al.*, 2013). The opportunity costs for farmers adopting soil and stone bunds include: loss of valuable cropping land to bunds (Ludi, 1997; Wyatt, 2002) which for farmers is an important issue when land is scarce and which imposes revenue loss to farmers; additional labour requirements of household for construction and annual maintenance (Shiferaw & Holden,

2001; Stocking & Abel, 1989). PES schemes should pay for the farmers' opportunity costs. The stated preference (SP) of farm households' stated WTA compensation for adopting soil and stone bunds can be employed as an appropriate measure of the opportunity cost of adopting such technologies. The minimum compensation needed to motivate a farm household to accept a PES contract involving the construction of soil or stone bunds on a unit area of land is presumed to indicate the farmer's real opportunity cost per unit area of soil or stone bunds adoption.

2.2 Factors determining farmers' willingness to accept/preferences for conservation practices/technologies

The factors influencing preferences and WTA compensation for conservation practices and technologies have generally been categorised into: farm characteristics; farmer and household characteristics; socioeconomic; and, institutional factors by previous studies (see, e.g., Ayuba *et al.*, 2011; Cooper & Keim, 1996; Matta *et al.*, 2009; Minten, 2003).

Key farmer and household characteristics have generally been thought to include gender, age, level of education of household head, own labour, labour sufficiency of the household, and wealth status of the household. For example, Thurston (2006) observes that females have higher WTA than males in valuing environmental conservation. Stephen (2015) and Wang *et al.* (2019) also estimate higher WTA for females relative to males. Sangkapitux *et al.* (2009), PRESA/ICRAF (2010), Minten (2003), Stephen (2015), and Wang *et al.* (2019) all find a positive relationship between age and WTA compensation. However, this relationship is found to be significant by Sangkapitux *et al.* (2009), Minten (2003), Stephen (2015), and Wang *et al.* (2019) and insignificant by PRESA/ICRAF (2010). Feng *et al.* (2018) however observe a negative effect of age on WTA. Education has usually been found to have a positive influence on WTA for conservation/supply of environmental services (Ninan *et al.*, 2007; Wang *et al.*, 2018; Wang *et al.*, 2019; Xu *et al.*, 2015). Minten (2003) explains that more educated households, who have a higher reservation wage, prefer to put more effort in off-farm earnings and hence, prefer to practice agriculture in a more extensive manner. In contrast, Xiong and Kong (2017) and Yu and Cai (2015) observe a negative influence of education on WTA. Household size has been used as an index of the farm household's access to labour in most studies. PRESA/ICRAF (2010) find a significant negative effect of household size on WTA compensation for watershed services whilst Minten (2003) observes an insignificant positive influence of household size on WTA to give up slash and burn agriculture ('tavy) and an insignificant negative effect of household size on WTA to give up forest use in Madagascar. Stephen (2015), Xiong and Kong (2017), and Wang *et al.* (2019) all find a significant positive effect of household size on WTA. Sangkapitux *et al.* (2009) observe that poorer farmers have a higher willingness to engage in a compensation scheme for providing better ecological services, probably indicating a lower WTA for the supply of environmental services. Farmers who rely on income from farm and aquatic products have higher WTA (Stephen, 2015; Xiong & Kong, 2017).

Key farm characteristics include total farm size, level/severity of erosion on farm/plot, level of soil fertility of farm/plot, slope of plot, and location/region. Sukic (2001), Xiong and Kong (2017) and Wang *et al.* (2019) find statistically significant positive impact of

land size on WTA compensation for conservation practices whilst PRESA/ICRAF (2010) discovers an insignificant influence. Previous findings suggest that the higher the level of erosion and the lower the soil fertility, the higher the willingness to participate in a payment scheme (Sangkapitux *et al.*, 2009). This in turn suggests that farmers with severe farm erosion and low soil fertility are likely to demand less compensation for conservation practices than those with less severe erosion on their fields and more fertile soils. Farm location heavily influences WTA (Minten, 2003; Stephen, 2015; Xiong & Kong, 2017; Yu & Cai, 2015). Minten (2003) reports that households with more lowland (which are more flat) are willing to accept less for compensation, though the estimates are statistically insignificant. By contrast farming in highlands (likely to be steeper) is a significant determinant of WTA compensation.

Monthly income, adoption status, and previous participation of the household in a conservation programme/project are institutional and socio-economic factors that have been associated with WTA compensation. A positive relationship between income and WTA is observed by PRESA/ICRAF (2010) and Sukic (2001), though the effect is statistically significant and insignificant respectively. Xu *et al.* (2015), Yu and Cai (2015), and Wang *et al.* (2018) find the opposite, that is a negative influence of household income on WTA.

For non-market valuation, respondents may be unable to give their true preferences because they have had little prior experience with the item in question and so have trouble establishing their minimum WTA during a single survey (Cummings *et al.*, 1986). Household knowledge of the good being valued can be proxied by identifying households who have previously adopted the conservation practice of interest or taken part in wider conservation programmes or projects. The literature is, however, silent on the direction of influence on WTA of households' prior adoption of a practice/technology and participation in previous conservation projects. However, various studies have found farmers' environmental awareness and knowledge affect WTA positively (Feng *et al.*, 2018; Wang *et al.*, 2018; Xu *et al.*, 2015; Yu & Cai, 2015).

3. Estimation methodology

CV studies require questions as to whether respondents are prepared to pay or accept specified monetary amounts in the light of changes that will impact upon them (e.g. the adoption of a technology). Valuation studies often assume that respondents know their preferences with certainty, i.e. they know how much they would be willing to accept for ES provision. However, empirical evidence in the SP literature indicates that respondents are uncertain about their responses (Akter & Bennett, 2013; Akter *et al.*, 2008; Alberini *et al.*, 2003; Champ *et al.*, 1997; Ready *et al.*, 1995). This is mainly because respondents use a heuristic mode while processing information provided in any of several CV formats which tends to dominate over more systematic ways of information processing for decision-making (Bateman *et al.*, 2004). Unsurprisingly, the CV literature has spawned multiple forms of elicitation which are aimed at minimising or mitigating biases. One factor that leads to potential bias is that respondents may not know or be able to state with certainty their underlying preferences and forcing them to do so can induce bias (Akter & Bennett, 2013; Ariely *et al.*, 2003; Poe, 2016; Ready *et al.*, 2010). Uncertainty is an important aspect of many public goods, especially environmental goods (Mitchell & Carson, 1989) such

as produced by SWC technologies like stone and soil bunds. Preference uncertainty is a stochastic error term which comes about in hypothetical valuation scenarios as individuals do not know their true values of a good with certainty (Li & Mattsson, 1995). In the current study, the LB and UB are obtained based on the expansion approach of Broberg and Brännlund (2008), which takes uncertainty into consideration. This method can be termed the ‘multiple-bounded uncertainty choice’ (MBUC) approach. It has been argued that this approach is more intuitive, better fits the data, estimates mean and median WTP with better precision, is less sensitive to distributional assumptions, and it is better suited for policy analysis than other approaches (Broberg & Brännlund, 2008). The elicitation method employed here (and outlined in Section 4) is to give respondents a ‘payment card’ (a series of possible ranges) but allowing them to indicate whether they would pay for that amount with certainty or with some level of uncertainty. However, this approach also requires an adaptation to the standard methods used to model WTA/WTP.

A standard model for dealing with the case where the dependent variable is only known within a range is the interval data model (Stewart, 1983). Hanemann *et al.* (1991) observed that the interval-data model improves the statistical efficiency of WTP estimates by reducing the variance and point estimates of WTP models relative to single-bound models. Alberini (1995) explored the efficiency and biases of the estimates obtained from the bivariate probit and interval-data models and observed robust estimates for mean/median WTP and concludes that in the absence of perfect correlation as is the case in many CV studies, the interval-data model might be appropriate. However, the interval-data model assumes that answers provided by respondents reflect WTP/WTA which are known with certainty (Alberini, 1995). However, as discussed above, the elicitation approach outlined in Section 4 is more general in that it allows for uncertain responses. Because MBUC responses do not translate directly into the statistical models conventionally employed to model stated-preference responses, assumptions about the interpretation of the responses by the researcher are necessary. The literature provides a number of empirical ways to convert MBUC CV data to easily estimable forms. Intervals are obtained by assigning, $LB < y_i^* < UB$ given the responses, where LB and UB are the lower and upper bounds respectively.

The notation used in this section are adapted from Balcombe *et al.* (2009). If utility is unobserved and indicated by the latent variable y_i^* , and WTA_i is the WTA of the i th individual, then the utility can be expressed as:

$$WTA_i = y_i^* = \beta'x_i + \varepsilon_i \quad \varepsilon_i \sim N(0, h) \quad (1)$$

where x_i is a vector of explanatory variables determining respondents’ WTA, β' is the parameter vector related to x_i and ε_i is the error term assumed to be normally distributed with zero mean and variance h .

Consequently for WTA, the highest “definitely no” and lowest “definitely yes” responses form the LB and UB respectively. Uncertainties are accommodated in the model resulting in the uncertainty interval model which is employed in this study. The rule used to create the WTA interval for the i th individual is a function of his responses with the LB and UB constructed based on the following assumptions:

1. A ‘Y’: bid forms WTA_{upper}

2. A 'N': bid forms WTA_{lower}
3. A 'PY': bid forms WTA_{upper} with a fixed probability, τ
4. A 'PN': bid forms WTA_{lower} with a fixed probability, τ

where τ , a probability value of truncation, is between 0 and 1 and set by the authors at 0.75; Y is definitely yes, PY is probably yes, DK is don't know, PN is probably no, and N is definitely no.

The latent variable y_i^* therefore has the clear interpretation of a person's WTA, and equation (1) would give a direct estimate of the mean WTA.

For a Bayesian estimation and inference, priors for the β and h parameters are specified normal $N(.,.)$ and inverse gamma $IG(.,.)$ respectively:

$$\begin{aligned}\beta &\sim N(\underline{b}, \underline{V}) \\ h &\sim IG(n, s)\end{aligned}\tag{2}$$

The likelihood of the latent variable y^* is

$$p(y^*|x, \beta, h) = (2\pi)^{-\frac{n}{2}} h^{\frac{n}{2}} e^{-\frac{1}{2}h(y^*-x\beta)'(y^*-x\beta)}\tag{3}$$

The posterior distribution is obtained by combining equations (2) and (3). The posterior distribution of model (1) is simulated using the Gibbs sampler (see for example Koop, 2003).

Two models were estimated using the model above. The first one contains an estimate of the WTA which can be interpreted as describing the unconditional distribution of the WTA in the population (Verbeek, 2004). The second model includes the explanatory variables shown in Table 2 below.

The models were estimated using Markov Chain Monte Carlo (MCMC), setting the burn-in phase to 2000 iterations which is followed by another 200,000 iterations in which every 20th observation was sampled in order to lessen the dependence in the sequence, resulting eventually in 10,000 observations for analysis. Convergence diagnosis was done using visual plots of the sequences of values produced by the sampler and by modified t-tests for the hypothesis of 'no-difference' between the first and second halves of the sampled values for each of the parameters. Observations without either an upper or lower bound were not included in the analysis; hence none of the models was estimated with the total of 350 observations.¹

4. Field survey, data and variables

In a hypothetical conservation plan context, data were collected from 305 households in the three northern regions of Ghana through a survey conducted from January – March, 2010. The questionnaire used included a description of the technologies with pictures as well as pictures of the possible environmental consequences (i.e., landscape quality improvement/maintenance) of the technologies. A multi-stage sampling approach was adopted in which a district was first selected from each region. From a purposively

¹ Gauss code for estimation of the models written by Kelvin Balcombe.

Table 1. An example of an answered CV question.

Example: Which of the values would you be willing to accept for constructing **STONE BUNDS** on an acre of your own field? Please tick only one option for each value.

Amount in Cedis/acre	Definitely No	Probably No	Don't Know	Probably Yes	Definitely Yes
200	✓				
300	✓	✓			
350		✓			
400		✓			
450			✓		
500				✓	
550					✓
600					✓

selected group of communities in each district where physical evidence of the SWC structures of interest to the research are present, ten communities from two of the districts and five from the remaining district were then randomly chosen.² Finally, ten or five respondents were randomly selected from the 25 communities.

For the estimation of WTA, a CV of four polychotomous-choice multiple-bounded elicitation format with variations of yes/no answers to indicate respondent uncertainty (FAO, 2000; Mitchell & Carson, 1989). The dichotomous choice format with follow-up questions reasonably mimics the bargaining process common in developing countries (FAO, 2000) and hence familiar to respondents.

The CV consisted of a question format of eight bid amounts ranging from a minimum of GH¢200 to a maximum of GH¢600 for each of the technologies of interest, namely, stone bund and soil bund.³ These amounts were obtained from focus groups sessions and discussions with experts. Face-to-face interviews with respondents were conducted during the CV survey. Table 1 shows an example of a CV question format and how it should be answered and Table 2 presents a description of variables.

5. Results

5.1 Description of respondents

Descriptive and summary statistics of selected socio-economic and demographic characteristics of respondents, physical characteristics of farm/fields, and institutional characteristics are presented in Table 3. Out of the total of 305 survey respondents, approximately 78% are males. The dominance of male-headed households in the survey

² Physical evidence is important because for stated preference studies, knowledge and familiarity of the good being valued is useful.

³ The average exchange rate in 2009 was GH¢2.2024 and GH¢1.4132 to GB £1 and US\$1 respectively (BoG, 2010: p.51).

Table 2. Description and statistics of variables used to explain WTA.

Variable	Description
<i>Farmer and household characteristics</i>	
Gender	Gender of household head (Dummy, 1 if male, 0 if female)
Age	Age group of household head (1 = 20 – 30 years)
Education	Level of education (1 = no formal education)
Own labour	Number of household members working on farm
Labour sufficiency	Whether farm household has enough labour (Dummy, 1 if yes, 0 otherwise)
Wealth status	Index of household perception of wealth status (1 = rich)
<i>Farm characteristics</i>	
Farm size	Total farm size in hectares
Severity of erosion	Average index for perception of erosion on plots (1 = not severe)
Soil fertility	Average index for soil fertility level on plots (1 = very fertile)
Slope of farm	Average index of type of slope of plots (1 = flat)
North ¹	Location is northern region (Dummy, 1 if northern region, 0 otherwise)
UWest	Location is upper-west region (Dummy, 1 if upper-west, 0 otherwise)
<i>Socio-economic and institutional variables</i>	
Income	Index for monthly income (1 = below GH¢21.00)
Adoption	Adoption of SWC by household (Dummy, 1 if adopter, 0 otherwise)
Participation	Participation in previous conservation project (Dummy 1 if yes, 0 otherwise)
Member	Membership in farmer association (Dummy, 1 if member, 0 otherwise)

¹ To avoid the dummy variable trap (Greene, 2003), the Upper East region is used as reference location and therefore dropped from the models.

sample conforms to GLSS5 (2008), which reports that the proportion of male-headed households in the rural savannah areas (study area fall within this category) is 85%. The highest proportions of more than 36% of respondents are over 50 years of age, whilst 33% are under 41 years, and about 67% are over 40 years. It can be concluded that households involved in agriculture are headed more by older heads than by young ones. This could be the reason why the adoption of SWC technologies by farm households in the study area is low. Respondents have low levels of education. About 77% and only 15% of respondents have had no formal education and primary education respectively. Only 8% of farm household heads have had either secondary or higher level of education. With an average family size of nine (9) persons, households in the study area generally reflect the large household sizes typical of African villages and farm households. On average, 4 persons per household provide on-farm labour. Most households (71%) do not have enough own/household labour to perform farm production activities. This has important implications for the adoption of labour intensive soil and water conservation technologies like stone and soil bunds. This lack of adequate household labour is probably one of the reasons why adoption of these technologies is low in the study area. In terms of land holdings, the study area is generally characterized by small holdings. The average total farm size is 2 hectares, with minimum and maximum values of 0.40 and 6.20 hectares respectively. Only 31% of households have total land sizes greater than the mean value. The small farm sizes

may also indicate that households will have low willingness to adopt SWC technologies that take up too much of cropland.

In terms of the adoption of either one or both SWC technologies under consideration, 55% of the responding households are adopters. This distribution provides enough data to make comparisons between adopting and non-adopting households. An adopter household in this study is one that has already adopted any one or both of the technologies

Table 3. Sample descriptive and summary statistics.

Sample characteristic	District			Total sample
	Lawra (%) (n=103)	T-Nabdam (%) (n=100)	W-Mamprusi (%) (n=102)	Freq. (%) (n=305)
<i>Gender of household head</i>				
Male	74 (71.84)	84 (84.00)	79 (77.45)	237 (77.70)
Female	29 (28.16)	16 (16.00)	23 (22.55)	68 (22.30)
<i>Age group (years)</i>				
20 – 30	11 (10.68)	16 (16.00)	12 (11.76)	39 (12.79)
31 – 40	18 (17.48)	25 (25.00)	20 (31.37)	63 (20.66)
41 – 50	22 (21.36)	30 (30.00)	42 (72.55)	94 (30.82)
Over 50	52 (50.49)	29 (29.00)	28 (72.55)	109 (35.74)
<i>Level of education of household head</i>				
No formal education	83 (80.58)	64 (64.00)	89 (85.29)	234 (76.72)
Primary	13 (2.62)	21 (21.00)	12 (11.76)	46 (15.08)
Secondary	3 (2.91)	13 (13.00)	3 (2.94)	19 (6.23)
Tertiary	1 (0.97)	2 (2.00)	0	3 (0.98)
Other	3 (2.91)	0	0	3 (0.98)
<i>Adoption of conservation technology</i>				
Adopter	51 (49.51)	37 (37.00)	48 (47.06)	168 (55.08)
Non-adopter	52 (50.49)	63 (63.00)	54 (52.94)	137 (44.92)
<i>Participation in previous conservation programme/project</i>				
Participant	54(52.43)	41 (41.00)	78 (76.47)	173 (56.72)
Non-participant	49 (47.57)	59 (100.00)	24 (23.53)	132 (43.28)
<i>Membership of a group</i>				
Member	55 (53.40)	41 (41.00)	59 (57.84)	155 (50.82)
Non-member	48 (46.60)	59 (59.00)	43(42.16)	150 (49.18)
<i>Labour sufficiency</i>				
Yes	54 (52.43)	21 (21.00)	12 (11.76)	87 (28.52)
No	49 (47.57)	79 (79.00)	90 (88.24)	218 (71.48)
<i>Wealth status</i>				
Rich	18 (17.48)	5 (5.00)	20 (19.61)	43 (14.10)
Average	54 (52.43)	74 (74.00)	72 (70.59)	200 (65.57)
Poor	31 (30.10)	21 (21.00)	10 (9.80)	62 (20.33)

Sample characteristic	District		Total sample	
	Lawra (%) (n=103)	T-Nabdam (%) (n=100)	W-Mamprusi (%) (n=102)	Freq. (%) (n=305)
<i>Household monthly income group (GH¢)</i>				
Below 10	47 (45.63)	31 (31.00)	9 (8.82)	87 (28.52)
10 – 20	47 (45.63)	29 (29.00)	35 (34.31)	111 (36.39)
21 – 30	3 (2.91)	4 (4.00)	13 (12.75)	20 (6.56)
31– 40	0 (0.00)	4 (4.00)	10 (9.80)	14 (4.59)
41 – 50	2 (1.94)	9 (9.00)	11 (10.78)	22 (7.21)
Above 50	4 (3.88)	23 (23.00)	24 (23.53)	51 (16.72)
<i>Degradation problem in locality</i>				
Yes	101 (98.06)	90 (90.00)	102 (100.00)	293 (96.07)
No	2 (1.94)	10 (10.00)	0 (0.00)	12 (3.93)
<i>Severity of erosion</i>				
Not severe	29 (28.16)	22 (22.00)	18 (17.65)	69 (22.62)
Fairly severe	17 (16.50)	36 (36.00)	23 (22.55)	76 (24.92)
Severe	38 (36.89)	13 (13.000)	29 (27.45)	79 (25.90)
Very severe	19 (18.45)	29 (29.00)	33 (32.35)	81 (26.56)
<i>Soil fertility</i>				
Very fertile	0 (0.00)	13 (13.00)	9 (8.82)	22 (7.21)
Fertile	51 (49.51)	54 (54.00)	63 (61.76)	168 (55.08)
Not fertile	52 (50.49)	33 (33.00)	30 (29.41)	115 (37.70)
<i>Slope of farm</i>				
Flat	11 (10.68)	2 (2.00)	10 (9.80)	23 (7.54)
Fairly steep	72 (69.90)	68 (68.00)	39 (38.24)	179 (58.69)
Steep	14 (13.59)	25 (25.00)	50 (49.02)	89 (29.18)
Very steep	6 (5.83)	5 (5.00)	3 (2.94)	14 (4.59)
District	Mean	Stdv	Min	Max
<i>Own labour</i>				
Lawra	4.18	2.16	1	10
Talensi-Naddam	3.85	2.29	1	13
West-Mamprusi	3.49	1.58	1	9
Total sample	3.84	2.05	1	13
<i>Household size</i>				
Lawra-Nandom	8.36	2.98	2	16
Talensi-Naddam	8.75	3.56	2	18
West-Mamprusi	9.93	3.39	2	16
Total sample	9.01	3.38	2	18
<i>Total farm size (acres)</i>				
Lawra-Nandom	1.18	0.68	0.40	4.80
Talensi-Naddam	1.98	1.21	0.60	6.00
West-Mamprusi	2.84	1.53	0.60	6.20
Total sample	2.00	1.36	0.40	6.20

under consideration. Almost equal proportions of respondents belong to an organized farmer association/group. An important feature of these associations is labour sharing. A proportion of about 65% of households earn a monthly income (from all sources, both on and off-farm) below GH¢21.00 (\$14.87) and are categorised as poor based on the Ghana Living Standard Survey (GLSS5, 2008). However, from the farmers' own perspective, only 20% of them consider themselves as poor. Ninety-six percent (96%) of respondents think that land degradation is a problem in their area. Most households, 95%, report that erosion is a problem on their own farms/fields, whilst about 77% perceive the level of erosion as being fairly severe to very severe. However, only about 38% of respondents view their farms as infertile.

5.2 Upper and lower bounds of WTA

The distribution of lower and upper bounds of WTA are reported in Table 4. The lower and upper bounds represent amounts that respondents are not willing and willing to accept respectively. For stone bund, whilst the range GH¢500-875 (\$353.85-619.24)

Table 4. Distribution of lower and upper bounds of WTA for stone bund and soil bund.

WTA (GH¢/ hectare)	Lower bound		Upper bound	
	No. of responses (%)		No. of responses (%)	
Stone bunds				
250	31	(10.20)	0	(0.00)
500	104	(34.21)	1	(0.33)
750	88	(28.95)	13	(4.28)
875	49	(16.12)	23	(7.57)
1000	22	(7.24)	54	(17.76)
1125	6	(1.97)	62	(20.39)
1250	1	(0.33)	84	(27.63)
1375	3	(0.99)	48	(15.79)
1500	0	(0.00)	19	(6.25)
Total	304	100.00)	304	(100.00)
Soil bunds				
250	90	(30.00)	0	(0.00)
500	141	(47.00)	27	(8.91)
750	47	(15.67)	52	(17.16)
875	18	(6.00)	66	(21.78)
1000	4	(1.33)	64	(21.12)
1125	0	(0.00)	52	(17.16)
1250	0	(0.00)	38	(12.54)
1375	0	(0.00)	4	(1.32)
1500	0	(0.00)	0	(0.00)
Total	300	(100.00)	303	100.00)

Figures in parentheses are percentages.

form the most important range in terms of numbers reporting for the lower bound, it is GH¢1000-1375 (\$707.71-973.10) for the upper bound.

Amounts ranging from GH¢250-750 (\$176.92-530.78) and GH¢750-1250 (\$530.78-884.64) form the most important lower and upper ranges respectively for soil bund. The total numbers reporting are different for the two technologies because, in some cases, respondents do not have either an upper or lower bound and therefore the percentages are in respect of the numbers reporting for the bounds and not of the total sample of 305.

5.3 WTA estimates

Mean WTA/hectare for stone bunds and soil bunds are shown in Table 5. These estimates are the unconditional WTA in the population. Respondents are willing to accept GH¢922.08/hectare (US\$652.56) and GH¢714.92/hectare (US\$505.95) for stone bunds and soil bunds respectively. WTA for stone bund is GH¢207.16/hectare (US\$146.61) more than for soil bund because the construction of stone bunds is labour intensive.

Table 5. Interval data model estimates on farmers' WTA for stone bund and soil bund.

Technology	WTA(GH¢/hectare)	S.D
Stone bund	922.08	12.808
Soil bund	714.92	12.807

5.4 Determinants of WTA

The results of the estimation of the determinants of WTA for stone bunds and soil bunds are shown in Table 6. Irrespective of the conservation technology, farmer and household characteristics which have significant effect on WTA are gender, the number of household members working on farm, whether household has enough farm labour, and the households' perception of its wealth status, with their direction of influence being the same for stone and soil bunds. Soil fertility and the farm location of Northern region are the two farm characteristics variables that are significant determinants for both stone and soil bunds. For stone bunds, severity of erosion and the location of Upper-West region are significant determinants as well. Among the three socio-economic and institutional variables considered, only previous participation is found to be significant for both stone bunds while all three variables are important for soil bunds.

6. Discussion

Resource managers' WTA is important in the implementation of any PES aimed at restoring ES. Influencing factors of preferences and WTA compensation for conservation have been grouped into: farm characteristics; farmer and household characteris-

Table 6. Interval data model estimates on determinants of WTA/hectare for stone bund and soil bund.

Variable	Stone bund		Soil bund	
	Coefficient	S.D	Coefficient	S.D
Constant	789.22*	71.09	546.78*	67.33
<i>Farmer and household characteristics</i>				
Gender	52.61*	29.88	61.55*	30.16
Age	-4.53	12.35	00.93	12.05
Education	24.75*	17.59	17.47	17.87
Own labour	-5.81*	04.01	-9.55*	03.92
Labour sufficiency	55.48*	27.81	51.52*	28.30
Wealth status	52.60*	20.66	80.92*	19.96
<i>Farm characteristics</i>				
Farm size	-2.20	08.55	-9.64*	07.99
Severity of erosion	12.65*	11.22	09.85	10.03
Soil fertility	76.16*	20.54	82.93*	18.53
Slope of farm	09.82	17.66	11.71	16.42
Northern region	-36.62*	31.77	-185.43*	29.51
Upper-West region	93.51*	32.17	-11.74	29.36
<i>Socio-economic and institutional variables</i>				
Income	-3.83	11.14	-27.05*	10.59
Adoption	24.78	30.11	53.57*	27.98
Previous participation	-84.21*	30.25	-104.30*	28.29

Note: * pseudo t-value significant at 5%; Within Bayesian inference, the coefficient's confidence/credible interval excludes zero if the ratio of the estimate of the mean to the standard deviation exceeds 2.

tics; socioeconomic; and, institutional factors by previous studies (see, e.g., Ayuba *et al.*, 2011; Cooper & Keim, 1996; Matta *et al.*, 2009; Minten, 2003). In the current study, as is shown in Table 6, gender, the number of household members working on farm, whether household has enough farm labour, and the households' perception of its wealth status are the farmer and household characteristics significantly influencing WTA. The direction of influence of these factors on WTA for both stone and soil bunds is the same. The observed differences in all the coefficient estimates for stone and soil bunds, i.e., higher positive and lower negative for stone bunds and lower positive and higher negative for soil bunds is because it costs more to adopt stone bunds than soil bunds.

Households headed by females are willing to accept less than male household heads. Female are willing to accept GH¢52.22/hectare (\$36.98/hectare) and GH¢61.55/hectare (\$43.59/hectare) less than males for stone and soil bunds respectively. This result is contrary to Thurston (2006), Stephen (2015), and Wang *et al.* (2019) who found female respondents have higher WTA than male respondents in valuing environmental conservation. The dissimilarity between the genders may be due to a number of reasons. First, wage disparity between genders and weak negotiation skills of females; second, females

may not be fully aware of the effort required as construction of bunds is done by males in the study area; third, women consider conserving the environment as a personal benefit unlike men who focus on financial rewards; and finally, women see current levels of PES funding as more helpful and useful than do men (Schwartz, 2017). Households with higher number of members providing farm labour are willing to accept less for adoption. This could be because the higher the household members providing on-farm labour, the less that household would require hired labour. The WTA for own labour for stone and soil bunds are GH¢5.75/hectare (\$4.07/hectare) and GH¢9.55/hectare (\$6.76/hectare) respectively implying that an additional household member working on the farm leads to a reduction in the WTA/hectare accepted by these amounts. There is no plausible explanation for the positive influence of labour sufficiency on WTA. Households who perceive themselves as poor demand GH¢52.50/hectare (\$37.18/hectare) and GH¢80.92/hectare (\$57.31/hectare) less for stone and soil bunds respectively than those who perceive themselves of average wealth. This result is consistent with that of Sangkapitux *et al.* (2009) that poorer farmers have a higher willingness to engage in a compensation scheme for providing better ecological services, indicating a lower WTA for the supply of environmental services. Education is a significant determinant of WTA for only stone bunds. Consistent with Ninan *et al.* (2007), Wang *et al.* (2019), Wang *et al.* (2018), and Xu *et al.* (2015), the more educated the household head, the more the WTA and this is explained by Minten (2003) that more educated households have a higher reservation wage and thus prefer to put more effort in off-farm earnings. This is particularly true as stone bunds require much more effort than soil bunds. For example, farmers who have had primary education will accept GH¢24.75/hectare (\$17.53/hectare) more than farmers with no formal education. In contrast, Xiong and Kong (2017) and Yu and Cai (2015) observe a negative influence of education on WTA.

Two farm characteristics, soil fertility and the farm location of Northern Region are the significant determinants for both stone and soil bunds. For stone bunds, severity of erosion and the location of Upper-West region are significant determinants as well. As the fertility of soil becomes poorer, farmers demand more compensation. Farmers will accept GH¢76.16/hectare (\$53.94/hectare) more for stone bunds on fertile than on very fertile soil. Also the higher the severity of erosion, the more WTA wanted. More infertile soils and highly eroded lands require more resources to construct closer bunds which also mean that more productive land is lost to conservation structures. The severity of erosion is significant for stone bund but not soil bund because stone bunds are comparatively better at controlling erosion. This result does not agree with Sangkapitux *et al.* (2009) whose results on peoples' willingness to participate in payment schemes posits that the lower the soil fertility and severe the erosion, the lower the WTA demanded is likely to be.

For soil bund, farm size is a significant variable showing that the bigger the households' farm size, the less WTA those households are willing to accept. Farm size negatively influences WTA probably because the opportunity cost of committing land is less for large landholders than for small landholders. This result conforms to that of Minten (2003) but contradicts that of Sukic (2001), Xiong and Kong (2017), and Wang *et al.* (2019). Willingness-to-accept of farmers in Northern and Upper-West regions are less and more compared to Upper-East region respectively for stone bunds. Farmers in Northern Region are willing to accept GH¢36.62/hectare (\$25.93/hectare) less than their counter-

parts in the Upper East Region, whereas those in Upper-West Region demand higher, a mean of GH¢93.51/hectare (\$66.22/hectare) more than those in Upper East. Willingness-to-accept is more in the Upper-West because stones are more readily available on farms in Upper-East than in Upper-West where stones will need to be transported from elsewhere. In the case of Northern region, it is perhaps because though stones are not abundant here, lands are much more flatter here compared to those in Upper-West and Upper-East and therefore will require less labour and materials for construction. This result does show that location influences WTA as is found by Minten (2003), Stephen (2015), Yu and Cai (2015), and Xiong and Kong (2017).

Previous participation is found to be the only socio-economic and institutional variable significant for both stone bunds and soil bunds. Households that have participated in previous soil and water conservation projects are willing to accept GH¢84.21/hectare (\$59.64/hectare) less than households that have not. This result is also observed by PRESA/ICRAF(2010). Such result, Cummings *et al.*(1986) explained as respondents probably being unable to provide their true preferences because they have had little prior experience with the item being valued and thus have difficulty establishing their minimum WTA during a single survey. This explanation does not however tell us the direction of influence on WTA. However, various studies have found farmers' environmental awareness and knowledge affect WTA positively (Feng *et al.*, 2018; Wang *et al.*, 2018; Xu *et al.*, 2015; Yu & Cai, 2015).

For soil bunds, income and adoption affect WTA in a negative and positive way respectively. For instance, farmers in the monthly income range of GH¢21-30 (\$14.87-21.25) will accept GH¢27.05/hectare (\$19.16/hectare) than those earning GH¢31-40 (\$21.95-28.33) per month. The higher the income of the household, the less WTA they are willing to accept agrees with Xu *et al.* (2015), Yu and Cai (2015), and Wang *et al.* (2018) but is inconsistent with PRESA/ICRAF (2010). This result is however contradictory to the influence observed for the wealth status variable probably because wealth status is a variable measuring perception than actual wealth. The adoption variable has positive effect, indicating, for example, that adopter households demand GH¢53.57/hectare (\$66.22/hectare) more than non-adopter households. Adopter households have previous knowledge of the technology thus it is logical to assume that their WTA represent their true preferences. This result contradicts that of the participation variable in that previous experience leads to positive effect on WTA (i.e., adoption) and negative influence on WTA (i.e., previous participation) at the same time. The only explanation that can be given for this inconsistency is that adopters perhaps have better and more experience with the technology because they have actually adopted on their own fields than previous participants of projects who may not have adopted.

7. Conclusions

Factors like gender, the number of household members working on farm, whether household has enough farm labour, the households' perception of its wealth status, soil fertility, farm location and participation in previous conservation project are significant determinants of WTA for both soil and water conservation technologies/practices. However, other factors like education, farm size, severity of erosion and income also show that

the determinants of WTA may vary with technology and location and therefore results from one location and for one technology should be employed in another location and on another technology with care.

The fact that location effects are observed in the average amount of compensation that smallholders in northern Ghana are prepared to accept indicates that location specific approaches might be employed, and that the amounts paid for the promotion of payment schemes should also be location specific. Particularly, smallholders in the Northern Region are willing to accept less for soil and stone bund than those in Upper East region and should be targeted.

A widely held argument in the literature is that poor smallholders are concerned about short-term but not long-term economic interests, and are, therefore, not willing to adopt sustainable management services. The fact that in the current study, households who perceived themselves as poor are willing to accept less than those who perceived themselves as rich suggests that the poorer groups among the farm households in northern Ghana are more willing to engage in conservation compensation schemes. Therefore, the evidence provided in the current study supports the proposition that compensation schemes can, in addition to their environmental objectives, address poverty.

To ensure effectiveness and efficiency of PES, policies should be designed to consider important factors. Factors such as gender, age, education, location, farm size, income, and previous participation in conservation programmes are important. Any category of household prepared to accept less compensation is more likely to participate in the PES scheme. Therefore, if a PES scheme will be implemented in the study, groups that need to be consciously targeted include: less educated and female headed households and households headed by older individuals. Compensation schemes should also concentrate more on poorer households than richer ones since this achieves both efficiency and equity objectives. Monetary compensation can be an avenue for improving livelihoods, alleviating poverty and diminish reliance of such groups on natural resources.

We briefly mention some limitations of our study. First, the high illiteracy rates of smallholder farmers impose some difficulties when conducting stated preference surveys in developing countries. Even after considerable training, enumerators may still make considerable mistakes. We tried to address this by reviewing each administered questionnaire at the end of each interview to highlight incorrect responses, and make sure that responses are corrected before leaving the respondents. Second, all valuation methods involve some uncertainty. The very complex nature of ES themselves limits how precisely they can be valued. The complexity limits the ability of respondents to understand and appreciate nature of ES or the reasoning behind the choices they make. We employed the MBUC CV format and the interval-data model to try and address the issue of uncertainty. Finally, the values attached to benefits from ES are subjective and variable over time, space and issue. These values differ substantially with people's attitudes, awareness of background issues, cultural norms, preferences and status. Additionally, it is extensively known that valuation of ES is very context specific and should be informed by the viewpoints and needs of the beneficiaries within these contexts. Thus the results obtained are space and time specific and apply only to a particular location. We reason that the results may well be extended to other parts of Ghana and perhaps SSA where conditions are similar, however, this should be done with care.

8. Acknowledgement

The authors are grateful to an anonymous referee for his valuable comments.

9. References

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